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71 Applicant: British Steel plc
9 Albert Embankment
London SE1 7SN(GB)

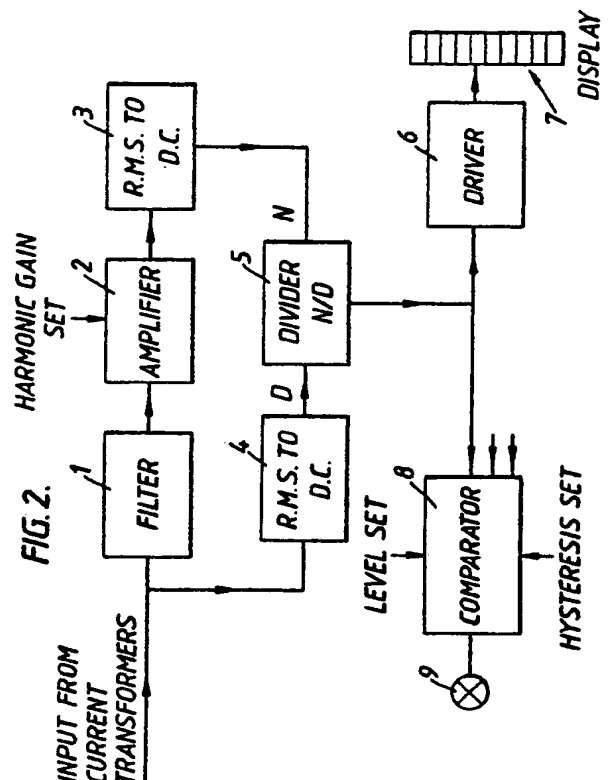
72 Inventor: Montgomery, Robert Walter
20 School Road Laughton-en-le Morthern
Nr. Sheffield Sth. Yorks(GB)

74 Representative: Broughton, Clifford David
British Steel plc Patent Section 9 Albert
Embankment
London SE1 7SN(GB)

54 **Arc exposure monitor.**

57 A method of monitoring the degree of exposure of an electric arc within a furnace having a molten charge, eg an arc furnace or ladle furnace, in which characteristic frequency spectra of the waveforms from the supply associated with (a) arc-exposure and (b) arc-submersion are predetermined and in which signals (eg indicative of the arc current) emitted during operation are measured and processed and a comparison effected with a set level established from these characteristic signals whereby to provide an indication of the degree of arc exposure.

The predetermined characteristic frequency spectra selected may be the harmonic content of the arc current.



ARC EXPOSURE MONITOR

This invention relates to a method of, and apparatus for, monitoring the degree of exposure of an arc within a furnace, e.g. an electric arc furnace during meltdown of a charge.

The current trend in arc furnace technology is to use one or more furnaces solely as melting units, and to perform steelmaking operations in a secondary vessel. The output rates of the equipment are matched to the throughput of a continuous casting machine. Large cost savings can be achieved if the melting requirements can be met by a single arc furnace. Furnace throughput is therefore of primary importance, and can be the limiting factor in the productivity of the plant.

In order to achieve the highest output from an arc furnace, it is essential to use the full power capability of the transformer for as high a proportion of the melting time as is practical. However, large energy losses may be incurred unless precautions are taken to ensure that a high heat transfer efficiency from the arcs to the steel is maintained, particularly during the periods during and approaching melt-out.

To achieve high efficiency, a technique has been developed for submerging the arcs in a deep foaming slag, thus containing the arc energy and transferring it into the steel melt. The normal bath decarburisation by oxygen lancing will often produce a deep foaming slag, but if foaming is to be maintained throughout the heat it is usually necessary to spray carbon or other foam inducing materials on to the slag surface as the carbon boil subsides.

On other occasions, where the bath metallurgy demands a high iron oxide slag content, it is not practical to maintain a foaming slag, and a lower transformer tap must be selected to reduce the arc length.

It is clearly beneficial therefore, for the furnace operators to be made aware of the state of submersion/exposure of the arcs, so that they can take corrective action by spraying carbon, or by reducing the voltage tap.

The state of submersion/exposure of an arc is also of interest in operating ladle furnaces where it is important to 'bury' the arcs beneath the slag to prevent erosion of the refractory lining.

It is an object of this invention to monitor the degree of arc exposure for the purposes aforesaid.

From one aspect the present invention provides a method of monitoring the degree of exposure of an electric arc within a furnace having a molten charge, in which characteristic frequency spectra of the waveforms from the supply associated with (a) arc-exposure and (b) arc-submersion

are predetermined and in which the supply signals emitted during operation are measured and processed and a comparison effected with a set level established from said predetermined characteristic spectra whereby to provide an indication of the degree of arc exposure.

The predetermined characteristic frequency spectrum selected is the harmonic content of the arc current; the signal processing is effective to determine from the arc current waveform the ratio of the harmonic level to the fundamental (50 cycles)

Essentially, this invention is based on the recognition that arcs are more stable when immersed in a slag; the slag reduces the arc mobility, i.e. the tendency to flare out in different directions from beneath the electrode and causes the arc to re-strike earlier in each mains cycle after each current zero. This in turn is reflected in the variation in the shape and amplitude of the arc current waveform.

This invention possesses the advantages that the measurements made are purely electrical (which is more reliable in the arc furnace environment than say acoustic monitoring), and no additional equipment for maintenance is required around the furnace. Further, each of the three arcs can be monitored independently, and while it is recognised that the three arc currents and their respective harmonics are not totally independent, it has been ascertained that the degree of harmonic content in each phase reflects the relative degree of arc exposure/submersion in that phase.

In order that the invention may be fully understood, one embodiment thereof will now be described, by way of example, with reference to the accompanying drawings, in which:-

Figures 1(a) and 1(b) illustrate the frequency analysis of arc current waveforms applicable to an exposed arc and a submerged arc, respectively, and

Figure 2 is a block diagram of the apparatus for performing the method of the invention.

Referring to Figure 1 the broad band frequency spectra of arc currents derived from existing current transformers in the furnace instrumentation are determined with exposed arcs - identified by visual and acoustic observations - and with submerged arcs. Both spectra illustrate the marked presence of third harmonics, and others to a lesser extent, which are indicative of the non-sinusoidal nature of the arc current waveform and the hesitancy of the arc to re-strike at current zero. As can be seen the significant difference between Figs. 1(a) and 1(b) is the larger area beneath the exposed arc spectrum

in the former case.

Considering now the apparatus shown in Figure 2 the current signals, whose frequency spectra is typified in Figs 1(a) and/or (b), are applied to a high pass filter 1 to isolate the 50 cycle mains component and other low frequency components, amplified in an amplifier 2 and then converted in a circuit 3 to an equivalent r.m.s. dc signal. Likewise the 'unmodified' input signal is applied direct to a circuit 4 which again provides an equivalent r.m.s. dc signal, the two d.c. signals then being ratioed in a divider 5, the output from which is thus a signal representing the fractional harmonic content of the current.

This output signal is applied on the one hand to a 'driver' circuit 6 which operates a bar graph display 7 by which the fractional harmonic content is illuminated at the appropriate level and on the other hand to a comparator 8 to which a preset level signal is applied which, if exceeded by the d.c. signal input, illuminates an 'arc exposed' lamp 9. Like signals from the other phases are similarly applied to the comparator and the channel or channels which illuminate the lamp is/are readily identifiable on the display 7.

A 'hysteresis set' or damping signal is applied to the comparator to minimise spurious illumination of the lamp.

In operation illumination of the lamp may typically initiate carbon spraying on the melt to foam the slag and submerge the arc again; alternatively if carbon spraying is inappropriate a reduction in the voltage tap will achieve arc submersion.

Although the invention has been described with reference to the specific embodiment illustrated it is to be understood that various modifications may readily be made without departing from the scope of this invention, e.g. clearly other circuit configurations and indications of arc exposure/submersion may readily be adopted. Further a like system based on the measurement of arc voltage may be used but this parameter (arc voltage) cannot be measured directly; the system based on current is simpler.

Claims

1. A method of monitoring the degree of exposure of an electric arc within a furnace having a molten charge, characterised in that characteristic frequency spectra of the waveforms from the supply associated with (a) arc exposure and (b) arc submersion are predetermined and in which the supply signals emitted during operation are measured and processed (1-5) and a comparison effected (8) with a set level established from said pre-

determined characteristic spectra whereby to provide an indication (9) of the degree of arc exposure.

2. A method according to claim 1, characterised in that the characteristic frequency spectrum selected is the harmonic content of the arc current.

3. A method according to claim 2, characterised in that the measurement and processing is effective to provide a signal indicative of the fractional harmonic content of the current.

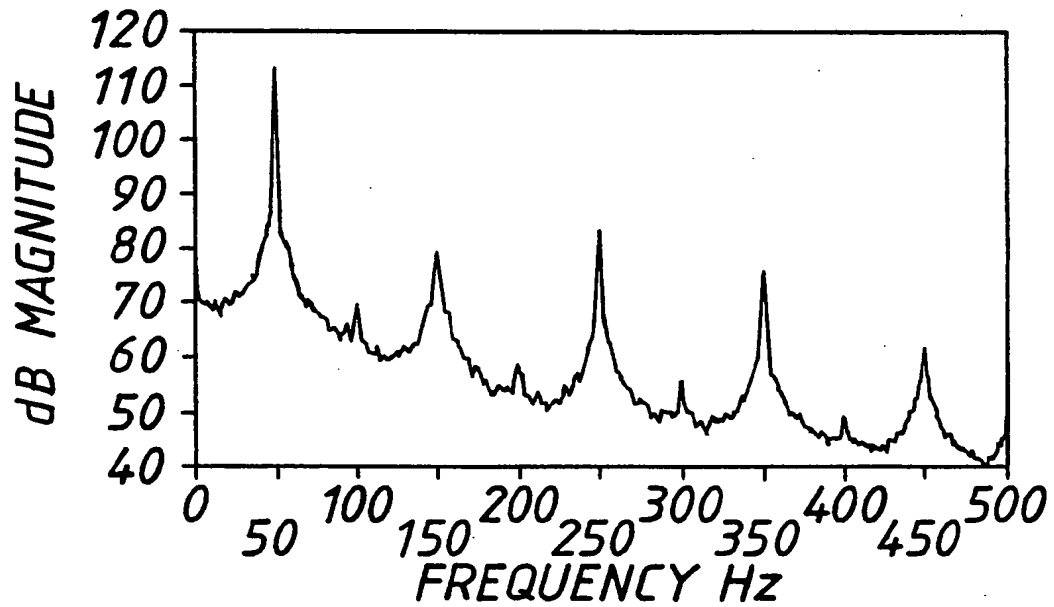
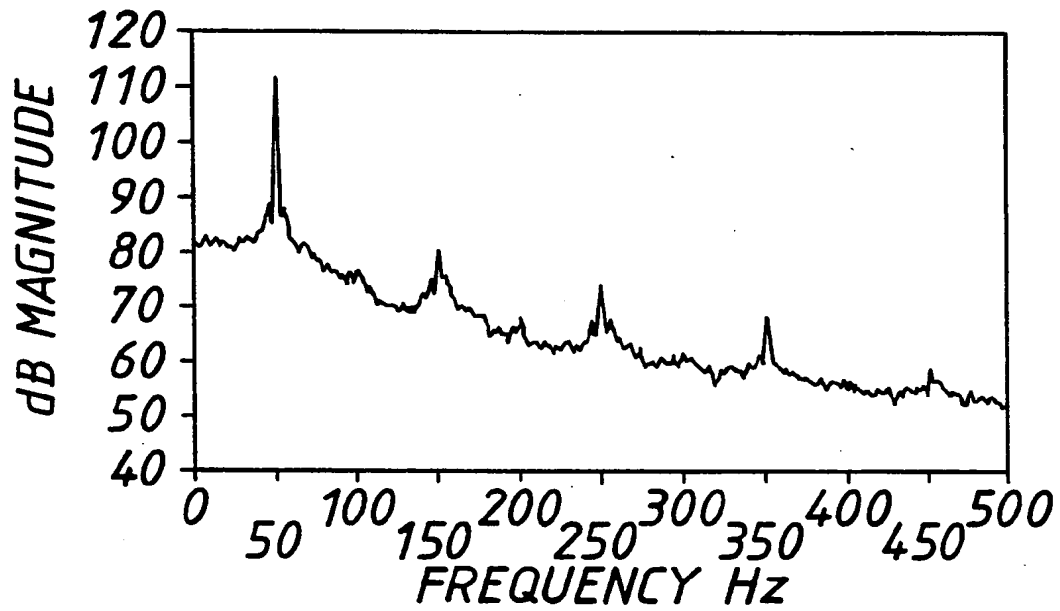
4. A method according to claim 3, characterised in that the supply signals are derived from current transformers associated with the furnace supply and are, in a first circuit (4), directly converted to an equivalent dc level and in a second circuit initially filtered through a high pass filter (1) and subsequently converted (3) to an equivalent dc level, the said signal indicative of the fractional harmonic content being derived from a ratioing circuit (5) to which said equivalent dc levels are applied.

5. The method according to claim 3 or claim 4, characterised in that the harmonic content selected is the third.

6. A method according to any one of claims 1 to 5, characterised in that, should the degree of arc exposure exceed a specified level, control action is automatically initiated to effect submersion of the arc.

7. Apparatus for monitoring the degree of exposure of an electric arc within a furnace having a molten charge, characterised by a first circuit (4) in which alternating signals derived directly from the furnace supply are converted to an equivalent dc level, a second circuit (1-3) in which said signals are transmitted through a high pass filter and subsequently converted to an equivalent dc level, a divider circuit (5) for ratioing the said dc signals and a comparator (8) for comparing the ratioed output with a set level established from characteristic frequency spectra of the waveforms of said alternating signals associated with (a) arc exposure and (b) arc submersion, whereby, when said set level is exceeded, an indication is provided of the degree of arc exposure.

8. Apparatus according to claim 7, characterised in that the characteristic frequency spectra selected is the harmonic content of the arc current, and in which the ratioed output is indicative of the fractional harmonic content of alternating current signals derived from the supply.

FIG. 1.**(a) EXPOSED ARC****(b) SUBMERGED ARC**

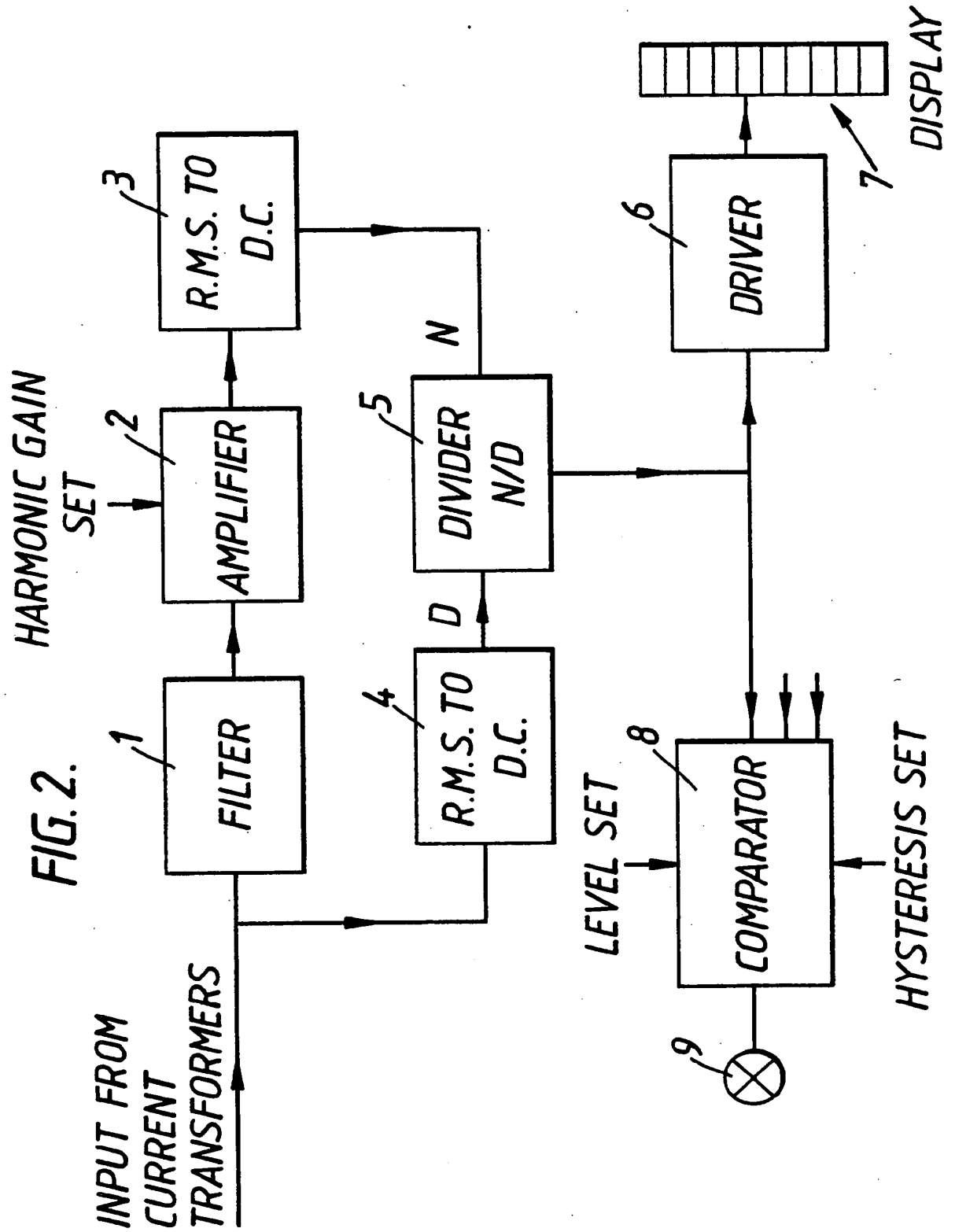
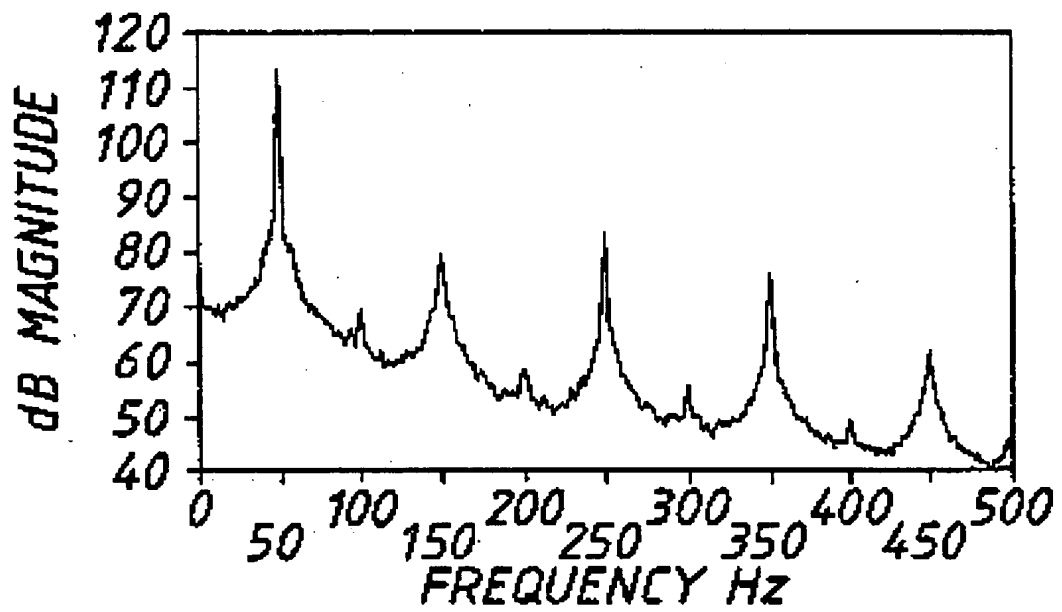
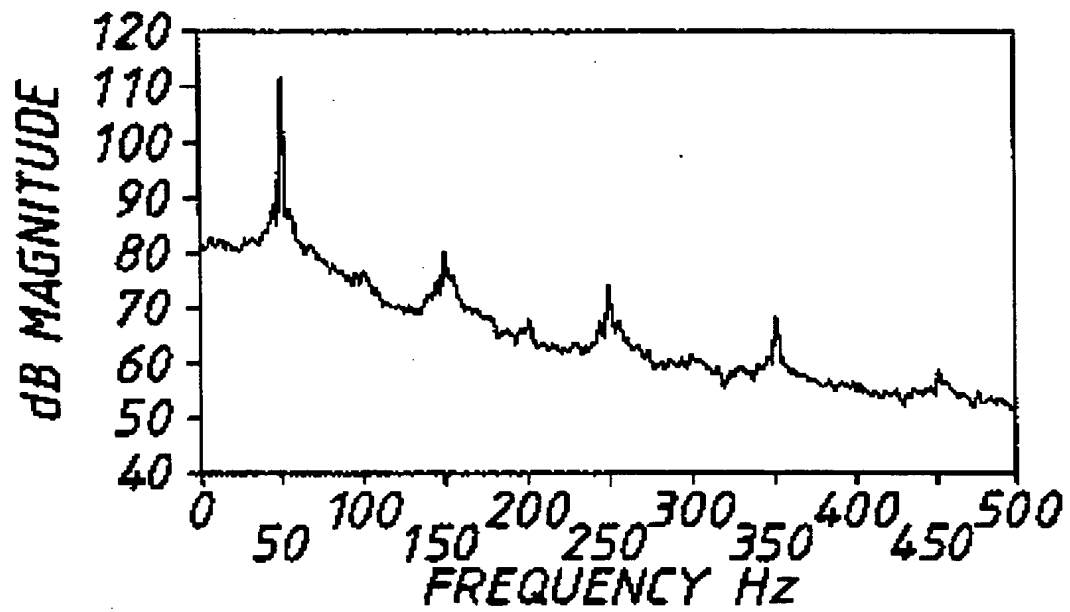
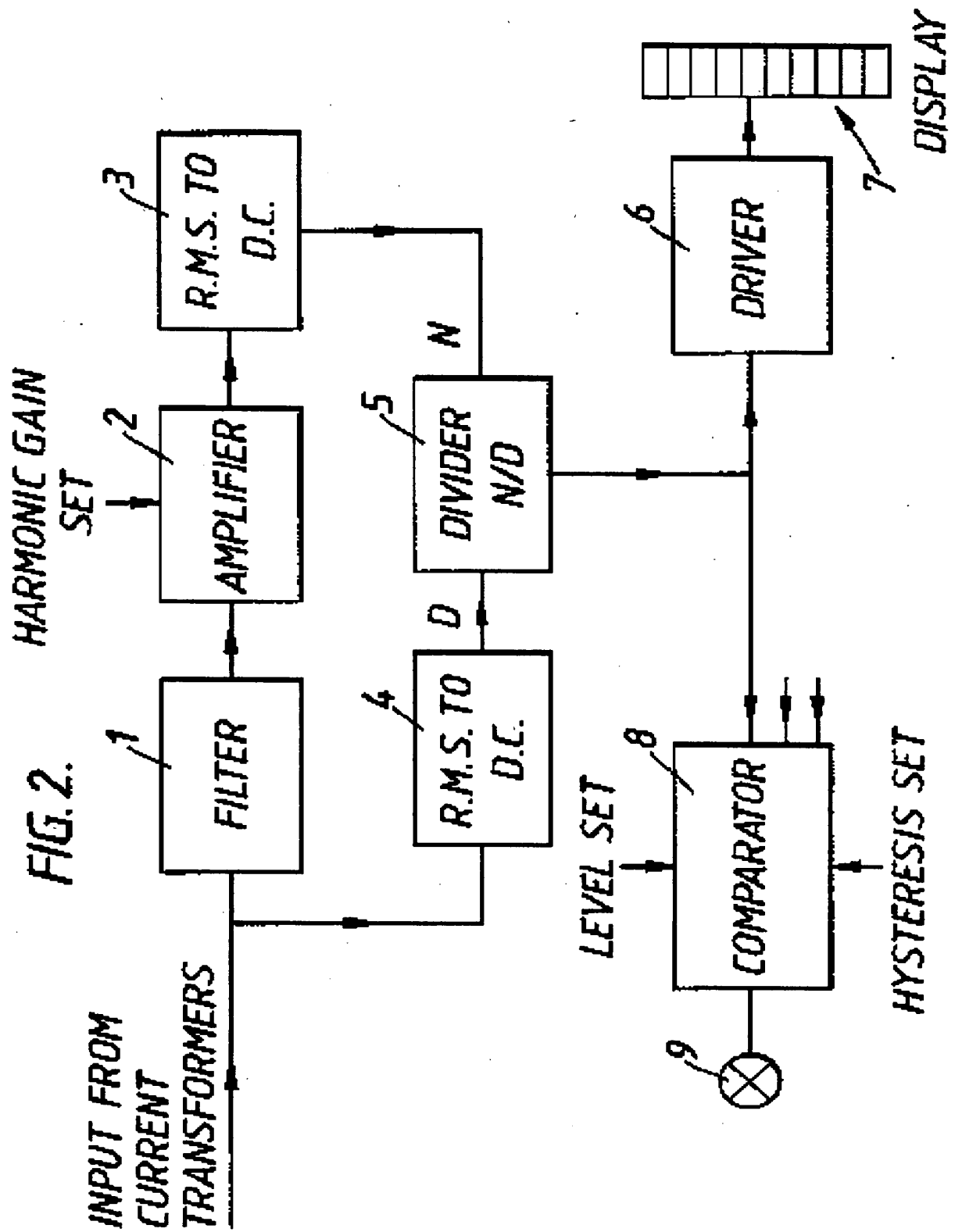


FIG. 1.**(a) EXPOSED ARC****(b) SUBMERGED ARC**



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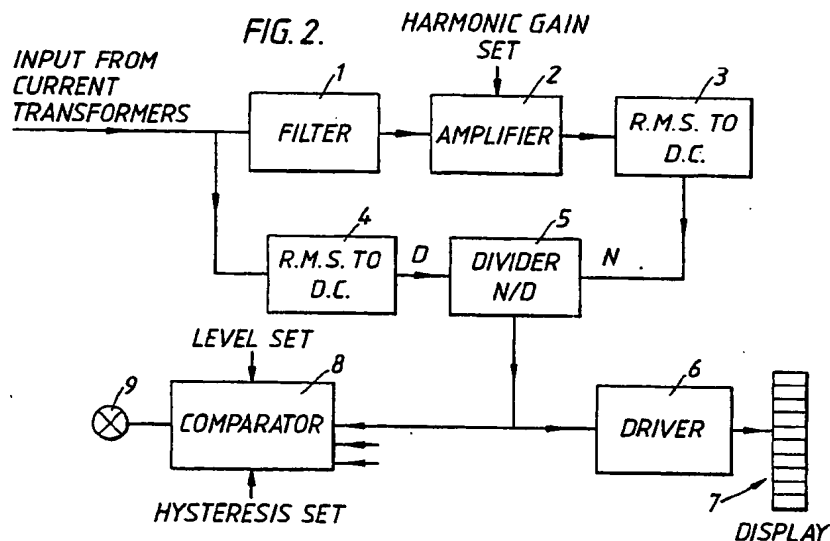
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15.05.91 Bulletin 91/20(71) Applicant: **British Steel plc**
9 Albert Embankment
London SE1 7SN(GB)(72) Inventor: **Montgomery, Robert Walter**
20 School Road Laughton-en-le Morthern
Nr. Sheffield Sth. Yorks(GB)(74) Representative: **Broughton, Clifford David**
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comparison effected with a set level established from these characteristic signals whereby to provide an indication of the degree of arc exposure.

The predetermined characteristic frequency spectra selected may be the harmonic content of the arc current.





European
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EUROPEAN SEARCH REPORT

Application Number

EP 88 11 9401

DOCUMENTS CONSIDERED TO BE RELEVANT			
Category	Citation of document with indication, where appropriate, of relevant passages	Relevant to claim	CLASSIFICATION OF THE APPLICATION (Int. Cl.5)
X	ELEKTROWARME INTERNATIONAL. vol. 45, no. 1, February 1987, ESSEN DE pages B29 - B36; K. Timm and R. Grigat: "Rechnergestützte Prozessbeobachtung des Schmelzvorganges im Lichtbogenofen" * page B33, left-hand column, line 31 - page B35, right-hand column, line 38; figures 7-9 *	1-3,5-6	H 05 B 7/144
X,A	DE-A-3 616 344 (THYSSEN STAHL AG) * page 3, lines 26 - 67; figures 1-3 *	1,2-8	
A	EP-A-0 066 502 (HYDRO-QUEBEC) * page 10, line 1 - page 11, line 10; figures 1, 4 *	4,7	
A	Iron and Steel Engineer vol. 44, no. 12, December 1967, Pittsburgh, USA pages 97 - 100; C.F. Rebhun et al.: "Use of Arc Voltage Characteristics As a Control for Consumable Electrode Melting"		
A	FR-A-2 072 181 (LEYBOLD-HERAEUS-VERWALTUNG GMBH)		
			TECHNICAL FIELDS SEARCHED (Int. Cl.5)
			H 05 B
The present search report has been drawn up for all claims			
Place of search		Date of completion of search	Examiner
The Hague		19 March 91	ALBERTSSON E.G.
CATEGORY OF CITED DOCUMENTS X: particularly relevant if taken alone Y: particularly relevant if combined with another document of the same category A: technological background O: non-written disclosure P: intermediate document T: theory or principle underlying the invention E: earlier patent document, but published on, or after the filing date D: document cited in the application L: document cited for other reasons &: member of the same patent family, corresponding document			